

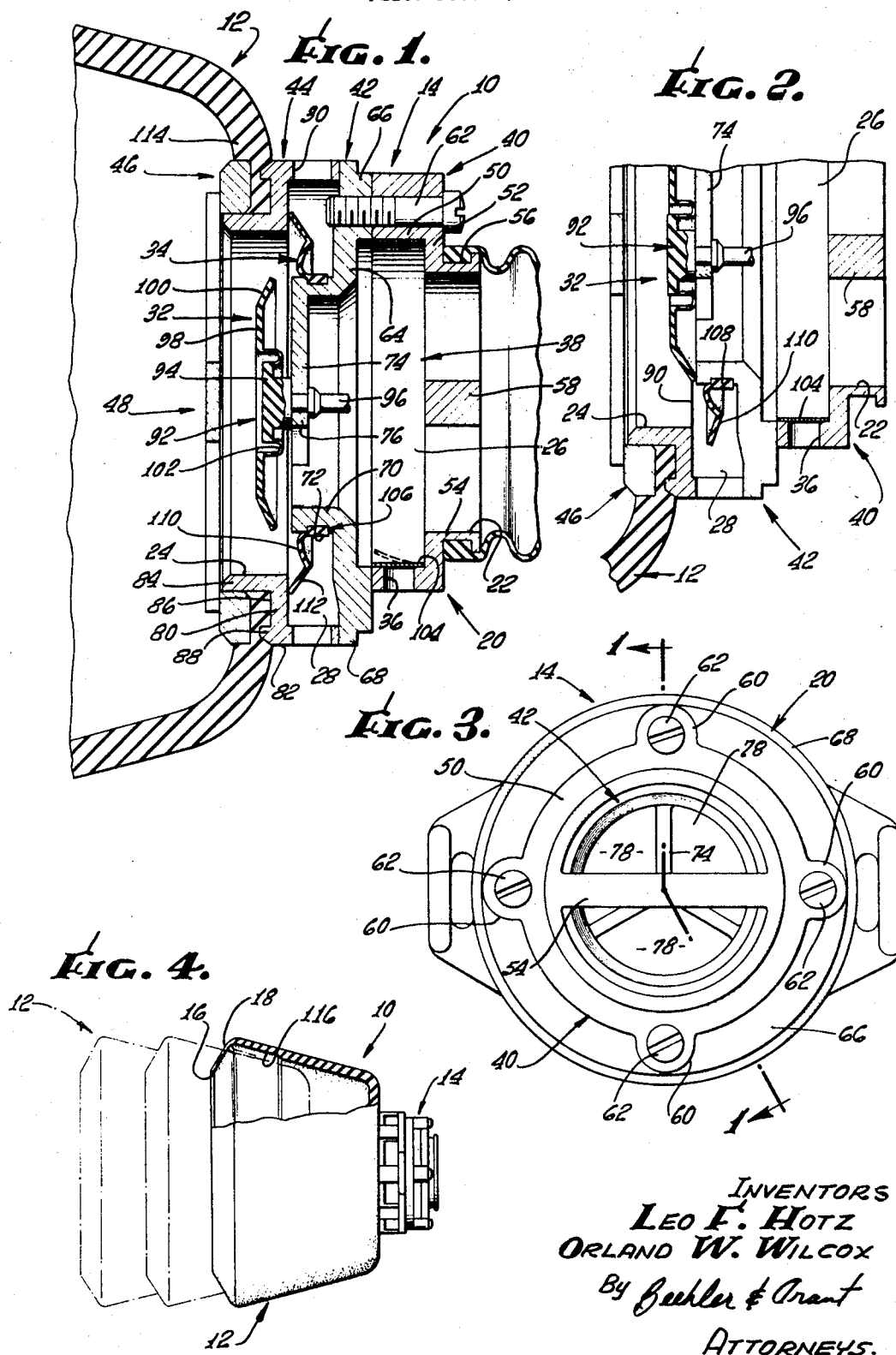
Sept. 16, 1969

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3,467,093

OXYGEN MASK AND VALVE STRUCTURE

Filed Dec. 9, 1966



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OXYGEN MASK AND VALVE STRUCTURE

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Filed Dec. 9, 1966, Ser. No. 600,509

Int. Cl. A62b 7/00

U.S. Cl. 128—146.5

3 Claims

ABSTRACT OF THE DISCLOSURE

In a breathing mask including a resilient cup having the general shape of a truncated cone with open ends and an inhalation and exhalation valve assembly mounted in the opening in the small end of the cup, the valve assembly comprising: a body having an inlet opening for receiving breathable gas from an external source, a breathing opening through which the mask user inhales and exhales, and an inhalation passage communicating said openings, an inhalation check valve means provided within the passage between the openings for permitting breathable gas to flow through the passage from the inlet opening to the breathing opening and blocking reverse flow through the passage, the body having an exhalation passage communicating at one end with the breathing opening in surrounding relation to the inhalation passage and opening at its other end to the atmosphere, an exhalation valve means in the exhalation passage for permitting the flow of exhaled air through the exhalation passage from the breathing opening to the atmosphere and blocking reverse flow through the exhalation passage, and the exhalation valve means being isolated from the breathable gas pressure in the inhalation passage upstream of the inhalation valve means, so that opening of the exhalation valve means is not resisted by the breathable gas pressure.

This invention relates generally to breathing apparatus for administering breathable gas to a subject. More particularly, the invention relates to improvements in breathing masks of the kind disclosed in Patent No. 3,158,153.

The breathing mask disclosed in the prior patent referred to above is intended primarily for emergency use in high altitude aircraft for administering oxygen-rich air to the aircraft crew and/or passengers. However, the improvements disclosed in the patent, as well as those contributed by the present invention, may be utilized to advantage in breathing masks for other purposes.

Generally speaking, the patented breathing mask comprises a resilient, essentially tubular mask body or cup having an opening in one end surrounded by a yieldable sealing rim which is adapted to be placed in seating contact with the user's face about his nose and mouth. This rim is sufficiently compliant to yield into conforming relation with the contour of the face and thereby form a substantially airtight seal between the cup and face. Mounted in the opposite end of the cup is an inhalation and exhalation valve assembly. This valve assembly embodies a first inhalation opening or inlet which receives a breathable gas such as oxygen from an external source through a flexible reservoir or breathing bag, a second inhalation opening or inlet to atmosphere, an exhalation opening to atmosphere, and inhalation and exhalation valve means which sequentially open and close as the mask user breathes to effect sequential admission of oxygen and ambient air to the user and exhausting of exhaled air to atmosphere. Important features of the patented mask reside in its simple, compact, light weight, low-cost, tamper proof construction, its non-oriented valve and cup configuration which renders unnecessary any particular orientation of the mask relative to the user's face

and thereby adapts the mask for emergency use, even by inexperienced persons, and in its unique inhalation valve construction which is effective to "top off" the pure oxygen from the external source with ambient air in such a way that during each inhalation phase the user initially breathes pure oxygen from the reservoir bag until the latter is emptied and thereafter supplementary air from the surrounding atmosphere.

The patented mask, however, has certain inherent deficiencies which this invention seeks to cure. One of these deficiencies resides in the fact that its inhalation and exhalation valves comprise valve members which undergo bodily movement between their open and closed positions. Also, the inhalation valve member is carried on and moves with the exhalation valve member and the latter valve member opens against the pressure of the oxygen supplied to the mask. As a consequence, the oxygen pressure resists or retards opening of the exhalation valve and thus creates an undesirable back pressure during exhalation. Because of the above factors, breathing through the patented mask is somewhat laborious.

Another deficiency of the patented mask is that while this mask has a construction which is greatly simplified in comparison to the earlier masks of the same general type, the patented mask, nevertheless, has a number of relatively complex parts which are somewhat difficult and costly to manufacture and assemble. Moreover, the flow characteristics of the mask, while satisfactory, are not ideal.

A further deficiency of the patented breathing mask involves the fact that the latter must be cleaned and sterilized periodically, as well as after each use. This requires removal of the masks from the aircraft or other location of use to a cleaning and sterilizing facility and subsequent return of the masks to their location of use. Owing to the large number of masks which need to be handled in this way, particularly in the case of a modern airliner, it is convenient to be able to stack the masks in a compact manner. The mask disclosed in the mentioned patent is deficient from this standpoint since it is incapable of being stacked with other like masks, at least with the masks disposed in compact nesting relation.

It is a general object of the present invention to provide an improved breathing mask and valve assembly therefor which embody all of the important features discussed above but are devoid of the noted deficiencies of the patented mask and valve assembly.

A more specific object of the invention is to provide a breathing mask and valve assembly of the character described wherein the inhalation and exhalation valves embody light weight, resiliently yieldable, flapper-like seating portions which yield or flex, rather than move bodily between their open and closed positions and which are urged or biased to their normal positions by the inherent resiliency of the seating portions, and wherein further the exhalation valve is isolated from the pressure of the oxygen supplied to the mask, whereby the resistance to opening of the exhalation valve, and hence the breathing effort involved in using the mask, are substantially reduced.

Another object of the invention is to provide a breathing mask of the character described which embodies a minimum number of simple light weight parts which may be economically fabricated and rapidly assembled to provide a simple, low cost, light weight, finished breathing mask which is ideally suited for emergency use in commercial airliners or the like.

A further object of the invention is to provide a breathing mask of the character described which is effective to dump excess oxygen to atmosphere in the event the rate at which oxygen is supplied to the mask exceeds the rate at which the oxygen is consumed by the user.

A further object of the invention is to provide an improved breathing mask of the character described which may be stacked with other like masks with the cups of the several masks disposed in compact nesting relation.

Other objects, advantages, and features of the invention will become readily evident as the description proceeds.

With these and other objects in view, the invention consists in the construction, arrangement, and combination of the various parts of the device, whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is an enlarged axial section, taken on line 1—1 of FIGURE 3, through an improved breathing mask according to the invention illustrating, in particular, the inhalation and exhalation valve assembly of the mask in the condition in which it exists during inhalation;

FIGURE 2 is a fragmentary showing of a portion of the valve assembly of FIGURE 1 illustrating the assembly in the condition in which it exists during exhalation;

FIGURE 3 is a view of the inlet end of the valve assembly in FIGURE 1; and

FIGURE 4 is a view, in reduced scale, illustrating a number of breathing masks stacked in nesting relation.

The breathing mask 10 of the invention which has been selected for illustration in the drawings comprises a resilient mask body or cup 12 and an inhalation and exhalation valve assembly 14 mounted in one end of the cup. The end of the cup 12 remote from the valve assembly 14 has an opening 16 surrounded by a resiliently yieldable or compliant rim 18. As will appear presently, the cup 12 is adapted to be placed over the wearer's face in such a way the cup rim 18 seats against the face in surrounding relation to the wearer's nose and mouth. The rim is sufficiently yieldable or compliant to conform to the contour of the face and thereby form a substantially airtight seal between the cup and face. The valve assembly 14 comprises a body 20 having an inlet opening 22 for communication to a source of breathable gas, such as oxygen, through an external reservoir or breathing bag (not shown), a breathing opening 24 communicating to the interior of the cup 12, and an inhalation passage 26 communicating these openings. Surrounding the downstream end of the inhalation passage 26 is an exhalation passage 28 which communicates with the breathing opening 24 and opens to atmosphere through a number of exhalation ports 30 in the valve body 20. Contained within the valve body 20 are concentric inhalation check valve means 32 and exhalation check valve means 34. The inhalation valve means 32 permit flow of oxygen through the inhalation passage 26 from the inlet opening 22 to the breathing opening 24 and block reverse flow through the passage. The exhalation valve means 34 permit flow of exhaled air through the exhalation passage 28 from the breathing opening 24 to the exhalation ports 30 and block reverse flow through the exhalation passage. Opening through the wall of the valve body 20, in the region between the inlet opening 22 and the inhalation valve means 32, is an air port 36 which communicates the inhalation passage 26 to atmosphere. Air flow through the port 36 is controlled by second ambient air inhalation valve means 38 which permit ambient air flow through the port into the inhalation passage and block reverse flow through the port.

In use of the breathing mask 10, the wearer places the mask cup 12 over his face in the manner mentioned earlier during each inhalation phase, the inhalation valve means 32 open and the exhalation valve means 34 close. Under these conditions, the user inhales oxygen from the external reservoir bag until the latter is emptied. The ambient air inhalation valve means 38 then open to supply supplementary air to the user during the remainder of each

inhalation phase. This action of supplying supplementary air to the user in the final portion of each inhalation phase is referred to as a "topping off" action. During each exhalation phase, the inhalation valve means 32, 38 close and the exhalation valve means 34 open. Under these conditions, the spent air exhaled by the wearer exhausts to atmosphere through the exhalation passage 28 and the exhalation ports 30.

Referring now in greater detail to the illustrated breathing mask 10, the valve body 20 comprises a composite body structure including four essentially annular members 40, 42, 44, 46, and a spider 48. These members are joined to one another and to the cup 12 to form a unitary mask structure. Body member 40 has a ring portion 50 with an inwardly directed end shoulder 52 from which axially extends a cylindrical flange 54. Flange 54 is externally circumferentially grooved at 56. The central opening through the flange 54 defines the inlet opening 22 of the valve assembly 14. Extending to the flange 54 is a reinforcing strut 58. Body member 40 has a number of integral bosses 60 which project radially from and are uniformly spaced about the ring 50. These bosses are drilled to receive bolts 62. The "topping off" air port 36 extends radially through the ring portion 50 of the body member 40.

Body member 42 comprises a generally flat ring portion 64 having a raised annular rim 66 extending axially from one side thereof which seats against the adjacent annular end face of the body member 40. Ring portion 64 extends radially out beyond the rim 66 to define an annular seating flange 68 and radially in beyond the rim to join an axially extending annular flange 70. Flange 70 is directed away from the body member 40 and is internally bevelled at its juncture with the ring portion 64, as shown. The outer surface of the flange 70 is circumferentially grooved at 72. Extending across the central opening through and integrally joined to the flange 70 is a spider-like partition 74 having a central portion 76 located on the axis of the valve body 20 and a number of openings 78 spaced about the central portion. As will appear presently, the partition or spider 74 forms part of the inhalation valve means 32.

Body member 44 comprises a flat ring portion 80, an outer annular flange 82 extending axially from the outer edge of the ring portion toward the body member 42, and an inner annular flange 84 extending axially from the inner edge of the ring portion away from the body member 42. The annular end face of the outer flange 82 seats against the adjacent face of the seating flange 68 on the body member 42. The exhalation ports 30 open through the flange 82, as shown. The outer annular face of the ring portion 80, that is the lefthand face of this ring as the latter is viewed in the drawings, has an annular groove 86 defining an annular lip 88 about the ring portion. The central opening through the inner flange 84 defines the breathing opening 24.

The remaining body member 46 is essentially a ring, edges of which are bevelled, as shown. Body ring 46 encircles and is internally dimensioned to receive with a close fit the inner flange 84 of the body member 44. Spider 48 extends across the ring 46, as shown.

The bolts 62 are threaded in the body member 42 and thus serve to releasably join this member and the body member 40. The outer flange 82 of the body member 44 is adhesively bonded or sonically welded to the seating flange 68 of the body member 42. Similarly, the body member or ring 46 is adhesively bonded or sonically welded to the spider 48 and to the inner flange 84 of the body member 44. It is evident at this point, therefore, that the several body members are rigidly joined to form a unitary body structure. The several members are coaxially arranged, as shown, and together define the inhalation and exhalation passages 26, 28. It is significant to note here that the partition or spider 74 extends across the inhala-

tion passage 26 between the breathable gas inlet opening 22 and the breathing opening 24. The exhalation passage 28 is formed by the annular cavity which is defined about the downstream end of the inhalation passage 26 by the ring portion 64 and flange 70 of the body member 42 and the ring portion and outer flange 72 of the body member 44. This annular cavity or exhalation passage communicates with the breathing opening 24 through an annular opening or clearance space 90 which is defined between the flange 70 of the body member 42 and the inner flange 84 of the body member 44.

The inhalation valve means 32 comprise a flapper-like check valve member 92 including a body having a central portion or pedestal 94 which is rigidly secured, by a fastener 96, to the central portion 76 of the spider 74. Valve 92 is located at the downstream side of this spider relative to the direction of flow through the spider openings 78. Surrounding the downstream end of the valve pedestal 94 is an annular resiliently yieldable valve seating flange 98 including a radially outer annular seating rim 100 and a radially inner annular fold 102 which joins the rim to the valve pedestal. The valve 92 may be molded in one unitary piece from a suitable resilient material.

The inherent resiliency of the valve seating flange 98, and particularly its annular fold 102, urges the flange away from the valve supporting spider 74 to the open position illustrated in FIGURE 1. When the mask user exhales into the mask cup 12, the pressure on the downstream side of the valve seating flange 98 may exceed the pressure on the upstream side of the flange. Under these conditions, the seating flange 98 yields toward and into seating contact with the downstream face of the spider 74 about its openings 78, as shown in FIGURE 2. The downstream face of the spider, therefore, furnishes a valve seat for the inhalation valve 92. When the user inhales, the pressure at the downstream side of the valve seating flange 98 is reduced and the latter returns to its open position of FIGURE 1.

In connection with this operation of the inhalation valve 92, it is significant to observe that the major yielding motion of the valve seating flange 98 occurs in its fold 102 and in such a way that the flange deflects or yields axially of the valve pedestal 94 between its open and closed positions. Minor yielding occurs in the flange rim 100 to accommodate effective sealing contact of the flange with its valve seat, about the entire circumference of the flange. The outer rim 100 of the seating flange is turned at an angle toward the spider 74, as shown, to aid this effective sealing engagement of the valve seating flange 98 with its valve seat.

The ambient air inhalation valve 38 comprises a thin resiliently yieldable valve band 104 which is positioned within the valve body member 40, in contact with the inner cylindrical surface of its ring portion 50. This valve band overlies and normally seals the topping off air port 36. As will be explained presently, the ambient air inhalation valve 38 remains closed during the initial portion of each inhalation phase and opens during the final portion of each inhalation phase to admit ambient topping off air to the inhalation passage 26.

The exhalation valve means 34 comprise a resilient annular flapper-like check valve means or ring 106 which may be molded from suitable resilient material. Valve ring 106 has a thickened inner rim 108 which seats in the groove 72 within the outer surface of the flange 70 of the valve body member 42. Extending radially out from this rim, across the annular exhalation opening 90, is an annular resiliently yieldable seating flange 110 which arches toward and then away from the breathing opening 24 and terminates in an outer seating rim 112. This rim overlaps and inclines toward the inner, righthand face of the ring portion 80 of the valve body member 44. The inherent resiliency of the valve seating flange 110 urges the latter into seating engagement with the latter face which furnishes an annular valve seat for the exhalation

valve. During each exhalation phase, the increase in pressure within the mask cup 12 urges the seating flange 110 of the exhalation valve 106 from its closed position of FIGURE 1 to its open position of FIGURE 2, thus to permit flow of exhaled air to atmosphere through the exhalation passage 28 and ports 30. During each inhalation phase, the valve normally returns to its closed position of FIGURE 1. It is significant to note in connection with this operation of the exhalation valve that the valve seating flange 110 yields resiliently between its open and closed positions. It is also significant to note that the exhalation valve is isolated from the pressure of the oxygen which is supplied to the mask through its inhalation passage 26 except when the rate at which oxygen is supplied to the mask exceeds the breathing requirements of the user. Under these latter conditions, the oxygen pressure may build up sufficiently to unseat the inhalation valve during exhalation or to unseat the exhalation valve during inhalation. In either case, the excess oxygen is dumped to atmosphere through the inhalation and exhalation valves, as hereinafter explained.

The mask cup 12 is constructed of a suitable yieldable or compliant material such as an elastomer. The end of the cup containing the valve assembly 14 turns inwardly to form a mounting flange 114 for the valve assembly. The inner circumferential edge of this flange fits between the ring portion 80 of the valve body member 44 and the valve body ring 46. As noted earlier, these valve body members are bonded to one another. The cup flange 114 is grooved to receive the lip 88 on the valve body member 44 and is recessed to receive the valve body ring 46, as shown, whereby the cup and valve assembly are firmly secured to one another. An important feature of the cup resides in its illustrated, generally frusto-conical shape which permits a number of the present breathing masks to be stacked with their cups disposed in nesting relation, as shown in FIGURE 4. When the cups are thus nested, the face sealing rims 18 of the cups are deflected inwardly between the adjacent cups, in a manner illustrated in broken lines in FIGURE 2. The inner surface of the cup 12 may be relieved adjacent the rim, as at 116, to provide clearance for the sealing rim when the latter is deflected into the cup during stacking and to afford the face engaging end of the cup with increased compliancy, thus to enable the cup to conform more closely to the contour of the user's face.

In use of the breathing mask 10, the inlet opening 22 of the mask valve assembly 20 is connected to a source of breathable gas, such as oxygen. In the drawings, for example, a flexible conduit 118 is secured to the inlet flange 54 of the valve assembly for conveying the breathable gas from its source to the mask. In practice, the breathable gas is delivered to the mask through a flexible reservoir or breathing bag (not shown) which is exposed to ambient air pressure. The cup 12 of the breathing mask is placed over the user's face in such a way that the sealing rim 18 of the mask seats against and conforms to the contour of the face about the nose and mouth, thus to provide an effective airtight seal between the cup and face. The user then breathes normally into the cup.

During the initial portion of each inhalation phase, the pressure of the breathable gas within the external reservoir or breathing bag, and hence within the inhalation passage 26, exceeds the ambient air pressure. Accordingly, the ambient air inhalation valve 38 remains closed, while the inhalation valve 32 opens to admit pure breathable gas from the bag to the user. This is the most useful portion of the inhalation phase because the user breathes the highest concentration of oxygen. This high concentration of oxygen enters the alveolar sacs of the user's lungs from which the oxygen is transmitted to the arterial blood flow to maintain a maximum level of oxygen arterial saturation. As soon as the breathable gas in the external reservoir bag has been depleted, which normally occurs during the final portion of each inhalation phase, the

pressure within the inhalation passage 26 drops sufficiently to create across the ambient air inhalation valve band 104 a pressure differential which deflects this band inwardly opposite the topping off air port 36, as illustrated in broken lines in FIGURE 1, thereby opening the port to admit supplementary topping off air to the inhalation passage from the surrounding atmosphere. During the final portion of each inhalation phase, therefore, the user breathes ambient air together with a small amount of the breathable gas or oxygen which continues to be supplied to the external reservoir bag from the external oxygen source. This final portion of each inhalation phase enables the user to fill his lungs, and thereby distend them to their normal extent. Assuring that the breathing requirements of the user equal the supply of breathable gas to the breathing mask, the inhalation valve 32 closes and the exhalation valve 34 opens during each exhalation phase to exhaust spent air to atmosphere through the exhalation ports 30.

In the event that the rate at which breathable gas is supplied to the mask exceeds the breathing requirements of the user, the pressure of the breathable gas may build up sufficiently to unseat the exhalation valve 34 during inhalation or to unseat the inhalation valve 32 during exhalation. Under these conditions, the excess breathable gas is dumped to atmosphere through the exhalation ports 30.

As noted earlier, one important advantage of the present breathing mask resides in the light weight yieldable construction of the inhalation and exhalation valves 32, 34. This valve construction enables the valves to rapidly open and close in response to minimum pressure differentials across the valves. Another important advantage of the mask resides in the fact that the exhalation valve does not unseat against the pressure of the breathable gas within the inhalation passage 26. Accordingly, this gas pressure does not impose any resistance to opening of the exhalation valve. These features of the breathing mask, therefore, permit breathing through the mask with minimum effort. A further important advantage of the mask resides in its non-oriented construction; that is to say, the mask may be applied to the user's face in any position. This non-oriented construction of the mask, which is due primarily to the symmetrical shape of the mask cup 12 and its sealing rim 18 and the concentric arrangement of its inhalation and exhalation valves, accommodates the mask for emergency use, even by inexperienced persons who have not been trained in its use. The stacking and nesting capability of the present breathing mask, discussed earlier in connection with FIGURE 4 of the drawings, constitutes an additional highly important advantage of the mask. As noted earlier, this latter feature of the mask is important owing to the necessity of periodic cleaning and sterilizing of the masks and resultant transportation of the masks, together with perhaps a great number of other like masks, from their location of use to a cleaning and sterilizing facility, and back to their location of use. An additional important advantage of the mask resides in its simple, light weight, low cost construction which is evident from the description and the drawings and uniquely adapts the mask for use in commercial airliners and other facilities where such features are critically important.

It is now obvious, therefore, that the invention herein described and illustrated is fully capable of attaining the various objects and advantages preliminarily set forth.

While the invention has herein been shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

What is claimed as new in support of Letters Patent is:

1. A breathing mask comprising:

a resilient cup having the general shape of a truncated cone,

said cup having a first opening in its small end, an inhalation and exhalation valve assembly in said opening,

said cup having a second opening in its large end bounded by a relatively thin resiliently yieldable sealing flange extending radially inward from the large end of said cup adapted for sealing engagement with the face of the wearer about his nose and mouth,

said sealing flange being yieldable into said cup whereby said mask is adapted to be stacked with other similar masks with the cups of adjacent masks fitting one inside of the other in nesting relationship,

said inhalation and exhalation valve assembly comprising,

a body having an inlet opening for receiving breathable gas from an external source, a breathing opening through which the mask user inhales and exhales, concentric inhalation and exhalation passages intermediate said inlet opening and said breathing opening communicating with said breathing opening for conveying a breathable gas to and exhaled air from said breathing opening, respectively,

inhalation check valve means within said inhalation passage comprising,

a partition rigidly joined to said body and extending across the downstream end of said inhalation passage, said partition having a central portion disposed substantially on the axis of said inhalation passage and a number of openings spaced about said central portion, a valve seat on the downstream side of said partition about said partition openings,

a valve member at the downstream side of said partition having a body including a central body portion rigidly secured to said central portion of said partition and an annular resiliently yieldable seating flange about the downstream end of said partition, said seating flange including an outer annular rim having a seating face confronting and engageable with said valve seat and an annular resilient fold joining said outer annular rim to said central body portion, said fold being resiliently yieldable to accommodate movement of said seating face axially of said central body portion into and from seating engagement with said valve seat, said seating flange being urged away from said valve seat by the inherent resiliency of said flange,

said exhalation passage comprising an annular cavity in said body about the downstream end of said inhalation passage, said annular cavity being defined by a first annular wall portion surrounding the downstream end of said inhalation passage and defining the radially inner wall of said cavity, a second annular wall portion concentric with and having an internal diameter greater than the external diameter of said first annular wall portion, and an annular shoulder extending radially inward from said second annular wall portion toward but out of contact with the downstream end of said first annular wall portion to define an annular opening between said first annular wall portion and the radially inner edge of said annular shoulder,

exhalation check valve means within said exhalation passage comprising, an exhalation valve seat on said annular shoulder surrounding said annular opening, an annular exhalation valve member constructed of resiliently yieldable material, said exhalation valve member surrounding and having its inner circumferential edge secured to said second annular wall portion, said exhalation valve member having an annular seating face confronting and engageable with said exhalation valve seat, the inherent resiliency of said exhalation valve member urging said seating face into seating contact with said exhalation valve seat

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to close said exhalation valve means, said exhalation valve member being resiliently yieldable away from said exhalation valve seat to open said valve means, and

an ambient air inhalation valve which comprises a thin resiliently yieldable valve band positioned over and normally sealing an ambient air port in said body upstream of said inhalation valve assembly, said valve band being resiliently yieldable out of sealing relationship with said ambient air port in response to an ambient air pressure greater than the pressure upstream of said inhalation valve.

2. A valve assembly according to claim 1 wherein: said partition comprises a spider integral with said first mentioned body.

3. A breathing mask according to claim 1 wherein: said small end of said cup has an inwardly directed annular flange, and

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said inhalation and exhalation valve assembly includes a body having means which straddle and grip therebetween said flange.

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